

# PATENT ABSTRACTS OF JAPAN

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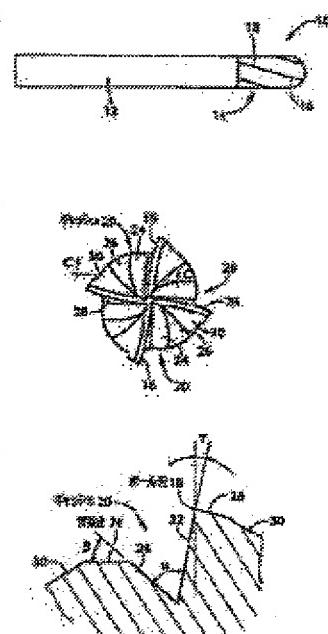
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## (54) MULTI-FLUTE BALL END MILL

### (57)Abstract:

PROBLEM TO BE SOLVED: To provide a practically satisfactory tool life even when carrying out highly efficient machining to a high hardness hard-to-cut material such as hardened steel.

SOLUTION: Every ball end cutting edge 16 provided along an end gash 20 reaches an axis vicinity, and axis side ends substantially abut on each other. In the end gash 20, a cross section is V-shaped, and an opening angle  $\alpha$  of the V-shape is within  $60^\circ$  to  $90^\circ$  and a rake angle  $\gamma$  is within  $-5^\circ$  to  $-20^\circ$ . Chamfered removable parts 26 are provided at opening rims on the opposite side of the ball end cutting edges 16 of the end gash 20. By this, a chip room for discharging chips becomes large, chip discharging performance in the axis vicinity is improved, and, owing to the combination of all the ball end cutting edges 16 being provided in the axis vicinity and the rake angle  $\gamma$  being negative, minute chipping and the occurrence of chipping are suppressed.



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CLAIMS

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[Claim(s)]

[Claim 1] A multi-edge ball end mill, wherein back omission of chamfered shapes is provided in said ball end cutting edge of said gash, and an opening edge of an opposite hand in a multi-edge ball end mill with which a ball end cutting edge of three or more sheets is formed in a hemispherical part at the tip of shaft orientations along with a gash, respectively.

[Claim 2] The multi-edge ball end mill according to claim 1, wherein all the ball end cutting edges reach to near an axial center, an axial center side edge part is nearly contacting mutually and rake angle gamma of an axial center side portion of this ball end cutting edge has constituted the shape of V type within the limits of -5 degree--20 degree in a section of said gash.

[Claim 3] Said multi-edge ball end mill is a three-sheet edge, and the difference angle alpha of the shape of V type of a section of said gash within the limits of 90 degrees - 110 degrees said back omission, The multi-edge ball end mill according to claim 2 providing so that it may open outside to a groove face side of said gash with the angle of inclination beta within the limits of 10 degrees - 40 degrees.

[Claim 4] Said multi-edge ball end mill is a four-sheet edge, and the difference angle alpha of the shape of V type of a section of said gash within the limits of 60 degrees - 90 degrees said back omission, The multi-edge ball end mill according to claim 2 providing so that it may open outside to a groove face side of said gash with the angle of inclination beta within the limits of 10 degrees - 35 degrees.

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

#### [0001]

[Field of the Invention]This invention relates to a multi-edge ball end mill, and relates to the multi-edge ball end mill with which the tool life which can be especially satisfied practically also to the unscrapable material of the higher hardness of hardening steel etc. is acquired.

#### [0002]

[Description of the Prior Art]The multi-edge ball end mill with which the ball end cutting edge of three or more sheets is formed in the hemispherical part at the tip of shaft orientations along with the gash, respectively is used for various kinds of cutting, such as a metallic mold. A ball end mill given in JP,H10-128611,A is the example, and in order to attain reinforcement, it is formed so that all the ball end cutting edges may reach to near an axial center and an axial center side edge part may nearly contact mutually.

#### [0003]

[Problem to be solved by the invention]However, also in such a multi-edge ball end mill, the scraps discharging efficiency near an axial center is especially bad. When highly efficient processing of a rapid feed etc. was performed to the unscrapable material of the higher hardness of hardening steel etc., there was a case where minute chipping and a deficit arose in the axial center side portion of a ball end cutting edge, and sufficient life improved effect was not necessarily acquired.

[0004]There is a place which succeeded in this invention against the background of the above situation, and is made into the purpose in a practically satisfying tool life being acquired, even when performing highly efficient processing to the unscrapable material of the higher hardness of hardening steel etc.

#### [0005]

[Means for solving problem]In a multi-edge ball end mill with which a ball end cutting edge of three or more sheets is formed in a hemispherical part at the tip of shaft orientations along with a gash, respectively as for the 1st invention in order to attain this purpose, Back omission of chamfered shapes is provided in said ball end cutting edge of said gash, and an opening edge of an opposite hand.

[0006]in a multi-edge ball end mill of the 1st invention, a ball end cutting edge of all (a) attains the 2nd invention to near an axial center, and an axial center side edge part is nearly contacting mutually -- (b) -- rake angle gamma of an axial center side portion of the ball end cutting edge within the limits of -5 degree--20 degree, (c) A section of said gash has constituted the shape of V type. Rake angle gamma is a rake angle on a section which is right-angled and includes a ball center to a gash.

[0007]The 3rd invention is (a) in a multi-edge ball end mill of the 2nd invention. Said multi-edge ball end mill is a three-sheet edge, (b) Within the limits of 90 degrees - 110 degrees, the difference angle alpha of the shape of V type of a section of said gash is (c). Said back omission is provided so that it may open outside to a groove face side of said gash with the angle of inclination beta within the limits of 10 degrees - 40 degrees.

[0008]The 4th invention is (a) in a multi-edge ball end mill of the 2nd invention. Said multi-edge ball end mill is a four-sheet edge, (b) Within the limits of 60 degrees - 90 degrees, the difference angle alpha of the shape of V type of a section of said gash is (c). Said back omission is provided so that it may open outside to a groove face side of said gash with the angle of inclination beta within the limits of 10 degrees - 35 degrees.

#### [0009]

[Effect of the Invention]In such a multi-edge ball end mill, Since back omission of chamfered shapes is provided in the ball end cutting edge of a gash, and the opening edge of the opposite hand, the chip room for discharging scraps becomes large, scraps discharging efficiency improves, generating of minute

chipping and the deficit resulting from scraps plugging is controlled, and a tool life improves.

[0010]By the case where all the ball end cutting edges attain the 2nd invention to near an axial center, and the axial center side edge part is nearly contacting mutually. Since the section of the gash has constituted the shape of V type, it is possible to secure said back omission and a conjointly comparatively big chip room also in near an axial center, and generating of minute chipping or a deficit is controlled. Since rake angle gamma of the axial center side portion of a ball end cutting edge is within the limits of -5 degree—20 degree, the cutting edge strength of a ball end cutting edge is fully secured, and a deficit is controlled much more effectively. Thereby, even when highly efficient processing of a rapid feed etc. is performed to the unscrappable material of the higher hardness of hardening steel etc., practically sufficient tool life comes to be acquired.

[0011]The 3rd invention relates to the multi-edge ball end mill of a three-sheet edge, and by within the limits whose difference angles alpha of the shape of V type of the section of a gash are 90 degrees ~ 110 degrees. Since back omission is provided with the angle of inclination beta of 10 degrees ~ 40 degrees to the groove face side of the gash, the chip room of sufficient size is securable, setting rake angle gamma as a suitable value like the 2nd invention.

[0012]The 4th invention relates to the multi-edge ball end mill of a four-sheet edge, and by within the limits whose difference angles alpha of the shape of V type of the section of a gash are 60 degrees ~ 90 degrees. Since back omission is provided with the angle of inclination beta of 10 degrees ~ 35 degrees to the groove face side of the gash, the chip room of sufficient size is securable, setting rake angle gamma as a suitable value like the 2nd invention.

[0013]

[Mode for carrying out the invention]The multi-edge ball end mill of the 2nd invention – the 4th invention is suitably used, when performing highly efficient processing of a rapid feed etc. to the unscrappable material of the higher hardness of hardening steel, alloy tool steel, etc. especially, the multi-edge ball end mill of this invention, and, but it can be used also for other cutting.

[0014]As construction material of a multi-edge ball end mill, although nature tool materials of superhard, such as cemented carbide, are used suitably, other tool materials, such as high speed tool steel, can also be used. It is desirable to coat the surfaces, such as a cutting part, with hard coatings, such as TiAlN, TiN, and TiCN, if needed.

[0015]Back omission of chamfered shapes is right-angled to a gash, for example, and it is provided so that it may become linear shape in a section including a ball center, but it is also possible to provide so that it may curve to a convex configuration or concave shape. Although the depth range which provides back omission changes also with the sectional shape (the difference angle alpha, the depth, etc.) of a gash, or sizes of the angle of inclination beta, it is desirable to provide so that the groove face side height below back omission may become 2/3 or less [ of the groove face side height by the side of a ball end cutting edge (rake face side) ] and 1/2 or less, for example. Since the depth (groove face side height) of a gash is not necessarily constant and it generally becomes shallow gradually in an axial center side edge part, It is not necessary to necessarily provide in a fixed size throughout a gash also about back omission for example, and what is necessary is just to make it the remaining groove face side height become 2/3 or less [ of the groove face side height by the side of a ball end cutting edge ], and 1/2 or less in the maximum portion without the back.

[0016]If the angle of inclination beta without the back is small, while the enhancement effect of a chip room will not fully be obtained, since it may interfere with the No. 2 side (primary flank) etc. if large, said depth range becomes small, and the enhancement effect of a chip room is no longer obtained as a result. For this reason, within the limits of 10 degrees ~ about 45 degrees is suitable, for example. It may be made to change gradually although this angle of inclination beta can also be made into a fixed size in the whole region of a gash. Back omission changes the angle of the grinding stone for processing a gash, for example, and can form it by performing a grinding process by the same moving track as the time of gash processing, and the angle of inclination beta to the groove face side of a gash becomes fixed throughout a gash in that case.

[0017]Since the depth will become shallow and the cross-section area of a chip room will become small if large while a flute width size will become narrow and the discharging efficiency of scraps will fall, if the difference angle alpha of the shape of V type of the section of a gash is small, according to the number of ball end cutting edges, or rake angle gamma, are set up suitably, but: Within the limits of 60 degrees ~ about 120 degrees is suitable, when it is a three-sheet edge, within the limits of 90 degrees ~ 110 degrees is desirable, and when it is a four-sheet edge, within the limits of 60 degrees ~ 90 degrees is desirable.

[0018]Since sharpness will worsen if large to a negative side while in by the side of 0 degree or + a knife angle will become small and cutting edge strength will fall if small to a negative side namely, within the

limits which is about 0 degree--25 degree is suitable for rake angle gamma of the axial center side portion of a ball end cutting edge, and especially its within the limits that is -5 degree--20 degree is desirable. This rake angle gamma continues throughout a ball end cutting edge, and is good as within the limits of -5 degree--20 degree, and it is also more possible than the halfway point to consider it about 0 degree--5 degree or as + in the portion by the side of a periphery.

[0019]as for a ball end cutting edge, a periphery cutting edge in which it was desirable providing in spiral shape which goes to the periphery side from an axial center side edge part, which will be estranged from a tool tip if it is alike and follows and puts in another way, and which was alike, followed and was twisted to a cutting hand of cut and a counter direction, and it was twisted, for example by predetermined angle of torsion in the periphery side edge part is connected smoothly.

[0020]

[Working example]Hereafter, an embodiment of this invention is described in detail, referring to Drawings.

Drawing 1 is a figure explaining the multi-edge ball end mill 10 of the four-sheet edge which is one embodiment of this invention, and (a) is a front view seen from an axial center and rectangular directions, an expansion bottom view which (b) looked at from the tip 14, i.e., cutting part, side, and an enlarged drawing of a C-C section [ in / in (c) / (b) ]. This multi-edge ball end mill 10 has the shank 12 of cylindrical shape, and the cutting part 14 provided in a one end part of that shank 12, and to the cutting part 14. While the ball end cutting edge 16 of four sheets is formed in a circumference of an axial center by an equiangular distance (90-degree interval), the periphery cutting edge 18 is formed succeeding the ball end cutting edge 16. The ball end cutting edge 16 is formed in a hemispherical part at a tip of the cutting part 14 along with the gash 20, respectively, all the ball end cutting edges 16 have attained it to near an axial center, before performing web thinning, regret is carried out, width is 0.2 mm or less and an axial center side edge part of each ball end cutting edge 16 is nearly contacting mutually. it goes to the periphery side from an axial center side edge part -- if it is alike and follows and puts in another way, it will estrange from a tool tip -- it being alike, and, [ follow and ] It is provided in spiral shape twisted to a cutting hand of cut (it is the direction of left-handed rotation in a bottom face view of drawing 1 (b)), and a counter direction, and angle of torsion is smoothly connected to the periphery cutting edge 18 which is about 30 degrees. While the multi-edge ball end mill 10 of this example is constituted from cemented carbide by one, the surface of the cutting part 14 is coated with hard coating which comprises TiAlN.

Drawing 1 (c) is a sectional view which is right-angled and includes a ball center to the gash 20.

[0021]While the above-mentioned gash 20 was formed by a grinding process by a gash grinding stone, and a section has constituted the shape of V type so that clearly from drawing 1 (c), the difference angle alpha of the shape of the V type is carried out within the limits of 60 degrees - 90 degrees. And a rake face is constituted by one groove face side 22 by the side of the ball end cutting edge 16, and the rake angle gamma continues throughout the ball end cutting edge 16, and is carried out within the limits of -5 degree--20 degree. A rake angle of the periphery cutting edge 18 is within the limits of an about [-4 degree--6 degree].

[0022]The back omission 26 of chamfered shapes is formed in an opening side portion of the ball end cutting edge 16 of the gash 20 and the opening edge 24 of an opposite hand, i.e., a groove face side of another side, so that it may open outside with the angle of inclination beta to the groove face side 24. It is what was formed by the back omission's 26 changing an angle of a gash grinding stone into which the gash 20 was processed, and performing a grinding process by the same moving track as the time of gash processing, While becoming linear shape in sectional shape of drawing 1 (c), the angle of inclination beta to the groove face side 24 is approximately regulated throughout the gash 20, and it is considered as constant value within the limits of 10 degrees - 35 degrees in this example. Are becoming shallow gradually, and are changing one by one by a longitudinal direction of the gash 20 as the depth of the gash 20 is not constant and it goes to an axial center side edge part and a periphery side edge part from an omitted portion, a size, i.e., a depth range, without [ 26 ] the back, but. In a portion in which a depth range without [ 26 ] the back becomes the largest, height (length from a groove bottom to a ridgeline with the back omission 26) of the remaining groove face sides 24 below the back omission 26 is provided so that it may become 2/3 or less [ of height (length from a groove bottom to the ball end cutting edge 16) of the groove face side 22 by the side of the ball end cutting edge 16 ].

[0023]The No. 2 side (primary flank) 28 and the No. 3 side (secondary flank) 30 are smoothly formed in three dimensions in the ball end cutting edge 16 by predetermined angle of relief by ball grinding performed after gash grinding and back omission grinding.

[0024]Since the back omission 26 of chamfered shapes is formed in the ball end cutting edge 16 of the gash 20, and the opening edge of the opposite hand according to the multi-edge ball end mill 10 of such this example, The chip room for discharging scraps becomes large, scraps discharging efficiency improves,

generating of minute chipping and the deficit resulting from scraps plugging is controlled, and a tool life improves.

[0025]Although all the ball end cutting edges 16 reach to near an axial center and the axial center side edge part is nearly contacting mutually by this example especially, Since the section of the gash 20 has constituted the shape of V type, it is possible to secure said back omission 26 and a conjointly comparatively big chip room also in near an axial center, and generating of minute chipping or a deficit is controlled. Since rake angle gamma of the ball end cutting edge 16 is carried out within the limits of -5 degree—20 degree throughout an axial center side portion being included, the cutting edge strength of the ball end cutting edge 16 is fully secured, and a deficit is controlled much more effectively. Thereby, even when highly efficient processing of a rapid feed etc. is performed to the unscrapable material of the higher hardness of hardening steel etc., practically sufficient tool life comes to be acquired.

[0026]Although the multi-edge ball end mill 10 of this example is a four-sheet edge, By within the limits whose difference angles alpha of the shape of V type of a section of the gash 20 are 60 degrees – 90 degrees. A chip room of sufficient size is securable, setting rake angle gamma as a suitable value of -5 degree—20 degree within the limits as mentioned above, since back omission is provided to the groove face side 24 of the gash 20 with the angle of inclination beta within the limits of 10 degrees – 35 degrees.

[0027]Although the above-mentioned embodiment is a case where this invention is applied to the multi-edge ball end mill 10 of a four-sheet edge, as shown in drawing 2, this invention is also applicable to the multi-edge ball end mill 40 of a three-sheet edge.

[0028]The multi-edge ball end mill 40 of drawing 2 only differs in a number of cutting teeth, and other composition of it is substantially the same as that of said multi-edge ball end mill 10. Each ball end cutting edge 44 formed along with the gash 42 has reached to near an axial center, before performing web thinning, regret is carried out, width is 0.12 mm or less and an axial center side edge part is nearly contacting mutually. A rake face is constituted within the limits of 90 degrees – 110 degrees by one groove face side 46 by the side of the ball end cutting edge 44, and the rake angle gamma continues throughout the ball end cutting edge 44, and is carried out [ difference angle alpha of the shape of V type of a section of the gash 42 ] within the limits of -5 degree—20 degree. The back omission 50 of chamfered shapes is formed in the opening part of the ball end cutting edge 44 of the gash 42 and the opening edge 48 of an opposite hand, i.e., a groove face side of another side, so that it may open outside with the angle of inclination beta to the groove face side 48. The angle of inclination beta to the groove face side 48 is approximately regulated throughout the gash 42, and let the back omission 50 be the constant value within the limits of 10 degrees – 40 degrees by this example while it becomes linear shape in sectional shape of drawing 2 (b). Are becoming shallow gradually, and are changing one by one by a longitudinal direction of the gash 42 as the depth of the gash 42 is not constant and it goes to an axial center side edge part and a periphery side edge part from an omitted portion, a size, i.e., a depth range, without [ 50 ] the back, but. In a portion in which a depth range without [ 50 ] the back becomes the largest, height (length from a groove bottom to a ridgeline with the back omission 50) of the remaining groove face sides 48 below the back omission 50 is provided so that it may become 2/3 or less [ of height (length from a groove bottom to the ball end cutting edge 44) of the groove face side 46 by the side of the ball end cutting edge 44 ]. (a) of drawing 2 (b) is (b) of said drawing 1. It is a figure equivalent to (c), and the same mark is given to a portion which has the same operation substantially, and detailed explanation is omitted.

[0029]Also in such a multi-edge ball end mill 40, even when the same effect as said embodiment is acquired and highly efficient processing of a rapid feed etc. is performed to an unscrapable material of higher hardness of hardening steel etc., practically sufficient tool life comes to be acquired. Although this multi-edge ball end mill 40 is a three-sheet edge, By within the limits whose difference angles alpha of the shape of V type of a section of the gash 42 are 90 degrees – 110 degrees. A chip room of sufficient size is securable, setting rake angle gamma as a suitable value of -5 degree—20 degree within the limits, since back omission is provided to the groove face side 48 of the gash 42 with the angle of inclination beta within the limits of 10 degrees – 40 degrees.

[0030]While all the ball end cutting edges have reached to near an axial center, incidentally with a rake angle of gamma-10 degrees. While a ball end mill of the three-sheet edge whose angles of inclination beta 90 degrees and without the back of a section the difference angle alpha of a V type-like gash is 0 degree – 40 degrees, and all the ball end cutting edges have reached to near an axial center, A ball end mill of the four-sheet edge whose angles of inclination beta 60 degrees and without the back of a section the difference angle alpha of a V type-like gash is 0 degree – 40 degrees in a rake angle of gamma-10 degrees. When helical hole processing shown in drawing 3 was performed according to the following test conditions and a tool life was investigated using a ball end mill of a commercial two-sheet edge, a

three-sheet edge, and a four-sheet edge, a result shown in drawing 4 was obtained. A radius of a hemispherical part at a tip is [ a diameter dimension of 5 mm and a shank of each ball end mill ] 10 mm. Rake angle gamma is an approximately regulated size in the whole region of a ball end cutting edge. A thing with an angle of inclination [ without the back ] of beta= 0 degree is a comparison article without back omission among the "three-sheet edge" of drawing 4, and a "four-sheet edge", and an angle of inclination of beta= 25 degrees and a 40-degree thing comprise this invention article like said multi-edge ball end mill 40 or 10. With a two-sheet edge ball end mill which a ball end cutting edge of two sheets has attained to near an axial center, conventionally without back omission, "two marketing" is elegance and "three marketing", It is elegance conventionally without back omission in a three-sheet edge ball end mill which only a ball end cutting edge of one sheet has attained to near an axial center as a center cut tooth, and "four marketing" is elegance conventionally without back omission in a four-sheet edge ball end mill which only a ball end cutting edge of two sheets has attained to near an axial center as a center cut tooth.

(Test condition)

- Work material : SKD61 (50HRC)

- Processed hole : 15 mm in inside diameter, depth 10mm and tool revolving speed:6400min<sup>-1</sup>, feed-rate:1750 mm/min and Z-axis delivery:1mm / revolution and a coolant:air blow [0031]It turns out that the endurance which was most excellent in a three-sheet edge and a four-sheet edge when the angle of inclination beta without the back was 25 degrees is obtained so that clearly from drawing 4. In the case of a three-sheet edge, although the endurance in which the angle of inclination beta was comparatively excellent at least 40 degrees is obtained, when it is a four-sheet edge, if the angle of inclination beta will be 40 degrees, endurance will fall and it will become comparable as the case where he has no back omission.

[0032]As mentioned above, although the embodiment of this invention was described in detail based on Drawings, this is one embodiment to the last, and this invention can be carried out in the mode which added various change and improvement based on a person's skilled in the art knowledge.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1]It is a figure showing the multi-edge ball end mill which is one embodiment of this invention, and the expansion bottom view where (a) looked at a front view and (b) from the tip side, and (c) are the enlarged drawings of the C-C section in (b).

[Drawing 2]It is a figure showing another embodiment of this invention, and (a) is the bottom view seen from the tip side, and an enlarged drawing of a B-B section [ in / in (b) / (a) ].

[Drawing 3]It is a figure explaining the processing contents of the durability test which clarifies the effect of this invention and which went to accumulate.

[Drawing 4]It is a figure showing the result of the durability test of drawing 3.

[Explanations of letters or numerals]

10, 40:multi-edge ball-end-mill 16, 44:ball-end-cutting-edge 20, 42:gash 26, 50: Back omission

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[Translation done.]